

The ability of kelp forests to filter nearshore waters and impact water quality

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Background

- The role of kelp forests in altering concentrations of waterborne subsidies, and in sequestering these materials into nearshore food webs is fundamental to understanding the ecosystem function of kelp forests and their impact on coastal water quality.
- Primary producers take up nitrate as water passes through the forest, and invertebrates and fishes consume particulate organic carbon in the form of plankton, propagules and microbes.
- Despite its importance, the ability of kelp forests to act as filters for nearshore waters is poorly understood.



Filtering by sessile invertebrates



- Research in bays and estuaries has demonstrated that filtering of phytoplankton (microscopic plants suspended in the water) by invertebrates (mussels, clams, and oysters) fulfills key ecosystem functions such as maintenance of water clarity and control of eutrophication.
- Filter feeding invertebrates in kelp forests (bryozoans, sponges, clams and tunicates) may also have the potential to impact coastal water quality.

Kelp forests as filtering ecosystems



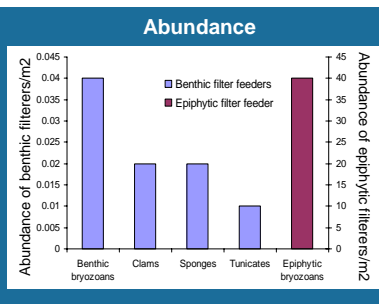
- In California many estuaries have been reduced or disappeared altogether. Runoff frequently enters coastal waters without being exposed to estuarine filtering.
- The coastal ecosystems in these areas are often characterized by kelp beds, supporting communities of suspension feeders, living on the bottom (benthic feeders) and all over the kelp (epiphytic feeders), that may function as alternative natural filters.

Approach

- Subtidal surveys and targeted experiments during 2005 at Mohawk reef in the Santa Barbara Channel.
- Monthly subtidal surveys (2002-present) at Mohawk reef.
- Literature survey to compare kelp forest filter feeding capacity to filtering by invertebrates in other ecosystems.



What are the factors that affect filtering capacity of kelp forest invertebrates?



- Epiphytic bryozoans grow on kelp throughout the water column.
- In 1 m² of reef, assuming a 5 m depth, epiphytic bryozoans cover 2 orders of magnitude more area than benthic bryozoans.
- Although the clearance rate of epiphytic feeders is lower than that of some benthic filter feeders, the extremely high abundance of epiphytic feeders suggests that these filterers will have a large impact on phytoplankton biomass and water quality.



Epiphytic filter feeder

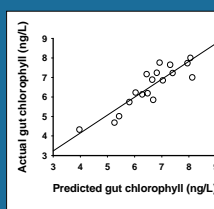
Clearance Rates

Filter-feeding invertebrates	Clearance rate (ml/zoo/hr)
Benthic bryozoans	
<i>Crisia</i> sp	0.2
<i>Bugula</i> sp	0.7
Epiphytic bryozoans	
<i>Membranipora</i> sp	0.3

Water flow and phytoplankton biomass

Multiple regression analysis examining the effects of current speed and plankton biomass on ingested biomass (biomass was estimated using chlorophyll concentration).

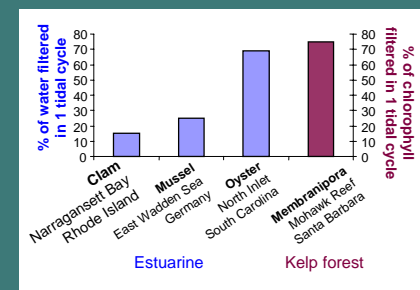
Source	df	F	model parameters	p
Current Speed	1	23.873	-0.18	0.0004
Plankton Biomass	1	5.6572	0.85	0.0349



78% of the variation in the actual concentration of chlorophyll in *Membranipora* guts is explained by a model including parameters for current speed and plankton biomass (linear regression, $r^2 = 0.78$, $p < 0.013$).

How does filtering in kelp forests compare to filtering in bays and estuaries?

Filtering capacity of kelp forest invertebrates compared to estuarine invertebrates

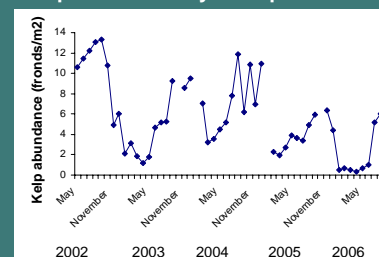


Epiphytic filter feeders in kelp forests are able to filter an amount that is comparable to filter-feeding invertebrates (mussels, clams and oysters) in bays and estuaries.

Will the dynamics of giant kelp populations alter filtering capacity of nearshore reefs?

- Giant kelp population abundance is highly variable in time, both intra-annually and inter-annually.
- Large variations in the abundance of kelp will lead to large variations in the abundance of epiphytic filter feeders that rely on kelp for substrate to grow.
- The filtering capacity of epiphytic feeders will likely be the highest from the late spring to early fall, when kelp abundance is the highest.

Temporal variability in kelp abundance



Implications

- Kelp forest invertebrates have the potential to limit phytoplankton abundance, and thus have the potential to increase water clarity and prevent eutrophication.
- In kelp forests, epiphytic filter feeders are the most abundant invertebrates, and thus remove the largest fraction of phytoplankton from the water.
- Clearance rates of the most abundant epiphytic filter-feeder, *Membranipora* spp., are high when phytoplankton biomass is high and current speed is slow. Thus kelp forests may provide a particularly important filtering mechanism in nearshore waters where water flow is not fast enough to remove phytoplankton blooms via physical transport processes.
- However, epiphytic filter feeders also rely on giant kelp for substrate and giant kelp abundance is highly variable in time. Thus the filtering capacity of nearshore reefs is likely to be high in some years and months and very low during others.